Extracorporeal Shock Wave Lithotripsy for urolithiasis; a single center study

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Abstract:

Introduction: The introduction of extracorporeal lithotripsy (ESWL) revolutionized the treatment of urinary stones since its invention in early 1980s.At many institutions, ESWL is the procedure of choice for proximal ureteric stones and renal stones.This paper analyzes and provides a general approach to the ESWL patients, discuss the outcomes and problems area, as well as to develop awareness among the patients necessitating stone management.

Methods: This was a prospective observational study. Total of 91 cases were included in this study. Patients from different clinics and OPD were selected for ESWL therapy. Study period were from Jan 2011 to June 2012. All the patients had undergone excretory urogram before selecting for the SWL in order to rule out distal obstruction and to assess the size of the stone and its location.

Results: More than 90 patients with renal and upper ureteric stones were subjected for ESWL over one and half years period (Jan 2011- Jun 2012) in an ESWL centre in Kathmandu.

Conclusion: ESWL is an effective and patient friendly means to treat upper urinary and renal stones. Stone size, and location greatly affect the stone free rate, morbidity and secondary procedures following ESWL.

Key Words: Fragmentation, Stones clearance, Steinstrasse

Introduction

Since the invention of the ESWL in the urology, its application has been tremendously been utilized to treat the urinary stones particularly renal and upper ureteric stones. It is approved by food and drug administration (FDA) of USA in 1984. Since its first clinical application in 1980, millions of people have been benefited. The indication of ESWL has rapidly extended from renal pelvis stones to almost all urinary stones[1]. The extraordinary success of the original Dornier HM3 lithotripter had tremendously appeal to patients and physicians alike. ESWL was established as the preferred initial treatment approach for 80% to 90% of calculi in the upper ureter or kidney of less than two cm size[2]. Percutaneous stone removal techniques were reserved for the small number of calculi deemed too large for treatment with ESWL, unusual anatomical circumstances such as caliceal diverticula or ESWL failures. Ureteroscopy was accepted as a suitable alternative to ESWL only for lower ureteral stones for which its increased invasiveness and requirement for ureteral stenting were offset by its high level of efficiency and efficacy[3]. In Nepal its use was initiated by Birendra Army hospital in 1990 and it is still in function.

In ESWL, shock waves are generated by a source external to the body and are then propagated into the patient's body and focused on the stone. Its uniqueness is that it exploits the shock waves and focus in to a particular point in side the body in such a way that is sufficient to break the stones. Four different potential mechanisms for ESWL stone breakage have been described like compression fracture, spallation, acoustic cavitation and dynamic fatigue [4].

Shock wave lithotripsy has been considered a mainstay of therapy for renal calculi for more than 20 years. Shock wave lithotripsy is noninvasive and requires the least anesthesia of the treatment modalities for treatment of renal calculi and therein lays its popularity. In the last decade, however, there have been changes in thinking regarding methods of patient selection for shock wave lithotripsy, changes in the technique of the existing shock wave lithotripters and new technologies designed to increase the efficacy of shock wave lithotripters. New studies have shown that shock wave lithotripsy may be less effective than other modalities for treating lower pole stones. Other existing technologies, such as computerized tomography, are being used to more effectively select patients for shock wave lithotripsy due to its Hounsfield unit measurement. Ongoing studies are evaluating changing the shock wave rate to increase stone fragmentation. In addition, efforts are being made to improve lithotripsy by designing more effective lithotripters [4].

The effectiveness, stone clearance and safety depend on the different factors including the age of the patient. The lower pole stones clearances will be difficult and takes lot more time than location of the other renal stones. Different factors are involved in this regard like the lower infundibulopelvic angle, caliceal pelvic height, lower infundibular length and diameter, lower infundibular length-to-diameter ratio and number of lower pole minor calices[5].

Efficacy and effectiveness will determine the clinical outcomes. Patient factor is most important other than the type of the machine we use. In our set up we have been using electrohydraulic lithotripter DIREX machine to break the stones.

In this prospective study we aim to analyze the outcome of ESWL for upper ureteral and renal stones, to observe the stones fragmentation and its clearances in relation to its size and location, as well as to observe the complications.

Methods

This was a prospective observational study. Total of 91 cases were included in this study. Patients from different clinics and OPD were selected for ESWL therapy. Study period were from Jan 2011 to June 2012. All the patients had undergone excretory urogram before selecting for the SWL in order to rule out distal obstruction and to assess the size of the stone and its location. Patients with recent urinary tract infection, bleeding disorders, distal obstruction, large stone burden and radiolucent stones were excluded. All the ESWL were done in Blue Cross Nursing Home Tripureshwor, Kathmandu. We used Digiscope RX2, Direx medical system, compact tripter, ellipsoid reflector with shock wave coupling with water cushion (Electro hydraulic lithotripter with inbuilt C- arm). Informed understanding written consent was taken in all cases. Double J stents were placed in those cases with stone size of about 2 cm, or in those patients who were apprehensive of steinstrasse and ureteric colic. Qualified anesthetist with diazepam and Ketamine provided sedation. Patients were monitored throughout the procedures including pulse, B.P. and oxygen saturation. SPSS 11.5 was used to calculate the data.

Results

In this series the youngest patient was seven years old and oldest being the 68 years.

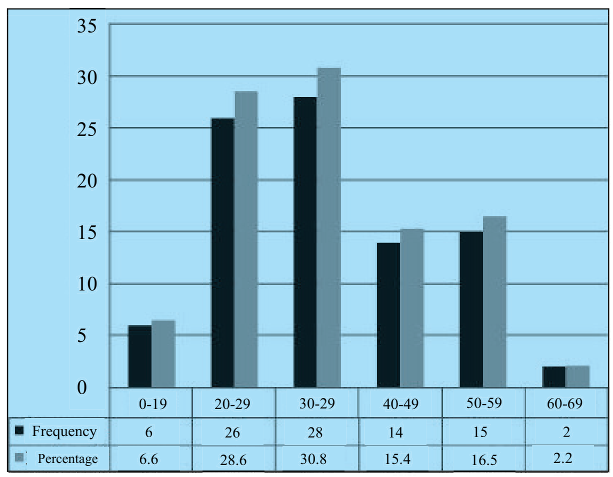

Figure1: Age distribution:

- Sex male: female 2:1, Weight varied between 35 -103 kg.
- DJ Stenting was done in 20 out of 91 cases.

Table 1: Disintegration in relation to size

Size	Completely	Partially	None	Total
< 1cm	13(76.5%)	3(7.6%)	1(5.9%)	17
1-2cm	31(72.1%)	10(23.3%)	2(4.7)	43
>2cm	14(45.2%)	17(54.8%)	0	31
Total	58	30	3	91
P value	0.028	0.006	0.436	0.025

Stones less than one cm were completely disintegrated in majority of the cases whereas stone size more than two cm were partially disintegrated.

Table: 2 Stone clearances in relation to size

Size	1week	2weeks	3weeks	3months	Total
<1cm	14(82.4%)	1(5.9%)	0	2(11.8%)	17
1-2cm	19(45.2%)	6(14.3%)	15(35.7%)	2(4.8%)	42
>2cm	9(29.0%)	5(16.1%)	10(32.3%)	7(25%)	32
Pvalue	0.002	0.589	0.017	0.071	0.006

Similarly, stone were cleared from the kidneys in one week in stone size less than two cm. It took longer time to clear for stone size more than two cm.

Table 3: Disintegration of stone in relation to location (Total Stone unit no=94)

Location	Complete	Partial	None	Total	p value
Upper calyx	4(57.1%)	2(28.6%)	1(14.3%)	7	0.238
mid calyx	13(76.5%)	4(23.5%)	0	17	0.409
Lower calyx	13(48.1%)	13(48.1%)	1(3.7%)	27	0.125
Pelvis	19(63.3%)	10(33.3%)	1(3.3)	30	0.998
Upper ureter	12(92.3%)	1(7.7%)	0	13	0.068

Lower calyceal stone disintegration was partial in almost 50% of the cases which required another session. It took longer time to clear the lower calyceal stone as compared to other locations

Table 4: Clearance of stones in relation to location (Total stone unit=94)

Location	Complete	Partial	None	Total	p value
Upper calyx	4(57.1%)	2(28.6%)	1(14.3%)	7	0.238
mid calyx	13(76.5%)	4(23.5%)	0	17	0.409
Lower calyx	13(48.1%)	13(48.1%)	1(3.7%)	27	0.125
Pelvis	19(63.3%)	10(33.3%)	1(3.3)	30	0.998
Upper ureter	12(92.3%)	1(7.7%)	0	13	0.068

Cases of complication on ESWL: N=91; Out of 91 ESWL

Renal: Transient hematuria: 78, and Extra-renal and gastro intestinal symptoms such as Nausea/vomiting (12); Ecchymosis (19); Steinstrasse (2) and Fever (1).

Table 5: Session required

Session	Frequency	Percentage
1	67	73.60%
2	20	22.00%
3	1	1.10%
4	2	2.20%
6	1	1.10%

Discussion

ESWL is an impressing way of dealing the urinary stones particularly of renal and upper ureter. It can be used for lower ureter and for the bladder calculi with special positioning, which it was not included in this study.

Extracorporeal shock wave lithotripsy (ESWL) has been successful for more than twenty years in treating patients with kidney stones. Hundreds of underwater shock waves are generated outside the patient's body and focused on the kidney stone. Stones fracture mainly due to spalling, cavitation and layer separation as described earlier. Cavitation bubbles are produced in the vicinity of the stone by the tensile phase of each shock wave. Bubbles expand, stabilize and finally collapse violently, creating stone-damaging secondary shock waves and microjets. Bubble collapse can be intensified by sending a second shock wave a few hundred microseconds after the first shockwave. A novel method of generating two piezoelectric generated shock waves with an adjustable time delay between 50 and 950 micros is described and tested [6].

Successful treatment of urinary calculi by ESWL depends on variable factors. Treatment success is defined as complete clearance of the stones with no residual fragments. Patient age, stone size, location and number, radiological renal features and congenital renal anomalies are prognostic factors determining stone clearance after ESWL of renal calculi [7]. Excretory urography has been done to determine the lower infundibulopelvic angle, caliceal pelvic height, lower infundibular length and diameter, lower infundibular length-to-diameter ratio and number of lower pole minor calices[8]. Stone-free status was assessed in our set-up by x-ray. Size and location has greater impact on successful stone management by ESWL. Stones size more than 2 cm and lower calyceal stones will have difficulties on clearance of the stones. So case selection and pre-treatment judgment is very crucial before the ESWL session. In our set-up, we always warn the patient regarding multiple sessions required for stones fragmentation and stones clearance. (Table 1&2) Extracorporeal shock wave lithotripsy appears to be successful for management of isolated caliceal stone disease. Treatment efficacy is not significantly different among stones localized in lower, middle and upper poles. It has been recommend as the primary treatment of choice for stones less than 2.0 cm. in all caliceal locations. Firstline management for renal stones between 2cm and 3 cm is controversial and frequency of treatment increases from 10 to 30% when ESWL used to treat stones of 1 to 2 and 2 to 3 cm respectively. Treatment should be individualized for management of caliceal stones greater than 2.0 cm until large prospective randomized trials comparing shock wave lithotripsy and percutaneous nephrolithotomy are available with very minimal morbidity to the patients [9]. The overall stones-free rate for SWL to lower pole stones is about 60%, compared to upper and middle pole calyces ranging from 70 to 90% [10]. In this study, disintegration was highest among the stone size less than 1 cm (76.5%) Whereas stone size more than 2cm it was only (45.2%). Most of the stones clearances achieved by three months time with stones size less than two cm. whereas it took more than three months for stones size greater than two cm. Stones in the pelvis with size 2 cm or equal are cleared more efficiently than stones of other locations. Regarding the stones in upper ureter, it has been shown that stones smaller than 1 cm, stone-free rate for ESWL was about 84% and stones larger than 1 cm was 77% and it has been suggested by various authors in past to deal such stones with ESWL. An impacted stone in ureter will tend to be more resistant to ESWL due to lack of liquid interface surrounding the stones [11].

In our study disintegration was good in mid calyceal, pelvic and upper ureteric stones with 76.5%, 63.3% and 92.3% respectively whereas it was lower disintegration for the upper and lower calyceal stones. (Table 3 & 4) Stones clearances were achieved mostly with upper calyceal, mid calyceal, pelvis and upper ureteric stones in first week time, whereas it took longer time to clear the stones fragment in lower calyceal stones in first and third week with 26.9%and 46.2% respectively. Five patients required three months to clear the stones (18.50%). (Table 4)

Composition of stone also has got role to play for stone fragmentation, though it was not included in this study. The ease with which stones of different composition may fragment differently. It has been reported that the stone fragility by percentage of stones fragmented with a given number of shock waves or by the number of shock waves needed to fragment stones to a given size. It has been shown that when adjusted for stone size, cystine and brushite stones are the most resistant stones to ESWL, followed by calcium oxalate monohydrate stones. Other in descending order, are hydroxyapatite, struvite, calcium oxalate dehydrate, and uric acid stones[12]. Stones composition can also affect the fragmentation and produce larger size, which are difficult to pass from the collecting system. So, it has been recommended with ESWL only when they are smaller than 1.5 cm (brushite, cystine and calcium oxalate mono hydrate). Larger stones are preferentially dealt by percutaneous nephrolithotomy. The ability to differentiate preoperatively different subgroup of stones composition and their fragility is difficult though different modality with the help of CT scan had been tried. Unfortunately not all stones are of the same chemical composition and to predict stone fragility would be a major breakthrough in stones management either by ESWL or by other alternative means. The CT attenuation value of renal calculi can help to differentiate stones that are likely to fragment easily on ESWL from those that would require a greater number of shock waves for fragmentation or may fail to fragment on ESWL [13,14].

Complications

No newer techniques are free of complications. So with the ESWL, but they are minimal and easily manageable. Most of the post ESWL complications are related to the passage of stone fragments. Likelihood of development of pain and colic are directly proportional to the size of the stone treated. Hematuria is the most common (100%) complication and occurs along with the ESWL and subsides within few hours to days. In our study it was found to have 89 out of 91 patients. Clinically apparent sepsis is very rare and UTI should be well treated before ESWL therapy. A peri-renal hemorrhage occurs in less than one percents of patient and occasionally, requires transfusion and very rarely, angiography and embolization.

Steinstrasse is the street of stones after ESWL, which are formed in the course of the ureter-giving rise to ureteric colic.It was found in two out of 91cases in the series. Indications for intervention are same like that of ureteric stone with colic. Majority of the patients did not have ureteric colic with ancillary ureterorenoscopic intervention. This is not alarming to the patients and should be accepted as post ESWL sequel unless complicated with clinical deterioration. ESWL is a form of renal trauma and has got some bioeffects, including hemorrhage, endothelial cell damage, glomerular atrophy and sclerosis, and interstitial fibrosis. Their effects in long-term are not well established[15]. Stone size and site, renal morphology and shock wave energy are the significant predictive factors controlling steinstrasse formation. If a patient has a high probability of steinstrasse formation, close follow-up with early intervention or prophylactic pre-ESWL ureteral stenting is indicated [16].

Conclusion

ESWL is a safe and efficient first-line therapy for treatment of isolated less than 2cm size kidney and upper ureteric stones with acceptable stone-free rates, low morbidity, few complications.

Conflict of interest: None declared

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